5

Technical Report No. 2

to the

Office of Naval Research

Contract Nonr-2868(00), NR 036-044/2-26-59

STRESS CORROSION CRACKING

D. van Rooyen

Westinghouse Electric Corporation
Research Laboratories
Pittsburgh 35, Pa.

January 19, 1960

Submitted for publication in the Journal of the Electrochemical Society.

STRESS CORROSION CRACKING

by

D. van Rooyen

Metals Joining Section
Metallurgy Department

January 19, 1960

WESTINGHOUSE ELECTRIC CORPORATION
RESEARCH LABORATORIES
Pittsburgh 35, Pa.

STRESS CORROSION CRACKING

D. van Rooyen
Research Engineer
Westinghouse Research Laboratories
Pittsburgh 35, Pennsylvania

ABSTRACT

Results show that nickel, even when stressed above its yield point, does not crack in boiling 42% magnesium chloride solution. Cracks do not initiate in nickel, and they do not propagate in this metal when initiated elsewhere. Tests were made with compound specimens, consisting of nickel bonded to stainless steel which is susceptible to cracking under the test conditions. Cracks initiated in, and propagated through, the steel but stopped when reaching the nickel boundary. No cracks were found in the nickel. Electrochemical measurements show that it is unlikely that the cracks were stopped by galvanic action between the different components. Results are consistent with a theory which explains the mechanism of stress corrosion cracking as being entirely electrochemical.(7)

STRESS CORROSION CRACKING

D. van Rooyen
Research Engineer
Westinghouse Research Laboratories
Pittsburgh 35, Pennsylvania

A mechanism in which stress corrosion cracks initiate and propagate in austenitic stainless steel in purely electrochemical stages was postulated by Hoar and Hines.[1-5] Such a mechanism is supported by recent work[6] which demonstrated that no steps of mechanical fracture could be detected at any stage of the cracking process of 18-8 type stainless steel in boiling magnesium chloride solutions. In order to account for observed rates of crack propagation, it was calculated that selective dissolution of the highly stressed advancing edge of a crack takes place at current densities of the order of 1 ampere per square centimeter. Hoar and West[7] demonstrated that 18-8 stainless steels can dissolve at such high current densities without much polarization, provided that the surface is yielding rapidly and provided that concentration polarization is avoided. They concluded that anodic dissolution is highly stimulated by the mechanically induced movement of the surface metal atoms. They further reported that similar tests on pure nickel gave no indication of such a mechanical effect in hot aqueous magnesium chloride.

While it is known that nickel and high nickel alloys do not suffer chloride stress corrosion cracking[8-13], it is uncertain whether their immunity arises in the initiation or in the propagation stage. It is important to know this, since the whole correlation made by Hoar and West between stainless steel and nickel is based on the assumption that cracks actually would not propagate into nickel under their conditions.

Studies on this mechanism of cracking are under way. Attempts are being made to compare the resistance of various alloys to crack propagation with their electrochemical behavior while corroding at high current densities in boiling magnesium chloride solutions. Specimens are prepared by arc depositing a layer of a susceptible material, such as 304 stainless steel, onto a strip of the material to be tested. The compound sample is then alternately rolled and vacuum annealed at 1065°C until the final thickness of about 0.045 inch is reached. The sample is given a final annealing treatment after machining the edges, and is placed under direct load while in contact with the test solution which is contained in a glass cell. The load is high enough to cause cracks to start in the susceptible alloy, and their behavior is then studied at the boundary by subsequent metallographic examination. Parallel tests are next carried out in the way described by Hoar and West.(7)

Results so far on nickel have confirmed the absence of mechanical stimulation of its anodic dissolution. Furthermore, stress corrosion cracks, which start in the 304 type stainless steel of a bonded specimen, proceed to the nickel boundary where they stop, Fig. 1. It can be seen that the cracks penetrate a short distance into the thin intermediate layer that exists between the sensitive alloy and the nickel. After crack formation and penetration in this particular experiment, the stress on the nickel was 43,000 psi, not allowing for any stress-raising effect at the tips of the cracks. A comparison of the electrochemical potentials of separate samples of stressed 304 type stainless steel and nickel showed that, apart from the first few minutes, the steel was more noble than the nickel. The potential curves are shown in Figs. 2 and 3. Consequently, it is not thought possible that a galvanic effect could account for the stopping of cracking at the boundary between the metals.

The results are in agreement with, and supply confirmation for, the electrochemical mechanism of cracking.(1-5)

Acknowledgment

The work reported was partly supported by the Navy Department, under Contract Nonr-2868(00) administered under the direction of the Office of Naval Research, Washington, D. C.

D. van Rooyen

LIST OF ILLUSTRATIONS